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(54) **WRIST MECHANISM FOR INDUSTRIAL ROBOT.**

(57) A wrist mechanism having a reduced size and improved acceleration/deceleration performance, wherein on the front face part of the wrist section mounted on the end part of a robot arm, provided is a first reduction gear of an α -rotating shaft whose axis is aligned with the γ -shaft axis of the robot arm; on the lateral face part of the wrist section, provided is a second reduction gear of a bending β -shaft perpendicular to the γ -shaft axis of the robot arm; on the shaft axis aligned with the γ -shaft axis, rotatably supported are inside and outside turning shafts; on the respective end parts of which bevel gears are mounted; to the bevel gear of the end part of the outside turning shaft, provided is a device which is

engaged with the input bevel gear of the bending β -shaft and performs the bending rotation of the wrist by the transmission of the rotation of the input bevel gear of the bending β -shaft; the bevel gear of the end part of the inside turning shaft is engaged with the gear mounted on the β -rotational shaft supported perpendicularly to the robot arm shaft; a bevel gear mechanism is provided at each of both ends of an inclined rotational shaft whose axis is at an acute angle to the β -rotational shaft center; and a device is provided which is engaged with the input bevel gear of the reduction gear of an α -turning shaft, and performs the turning of the wrist by the transmission of the rotation.

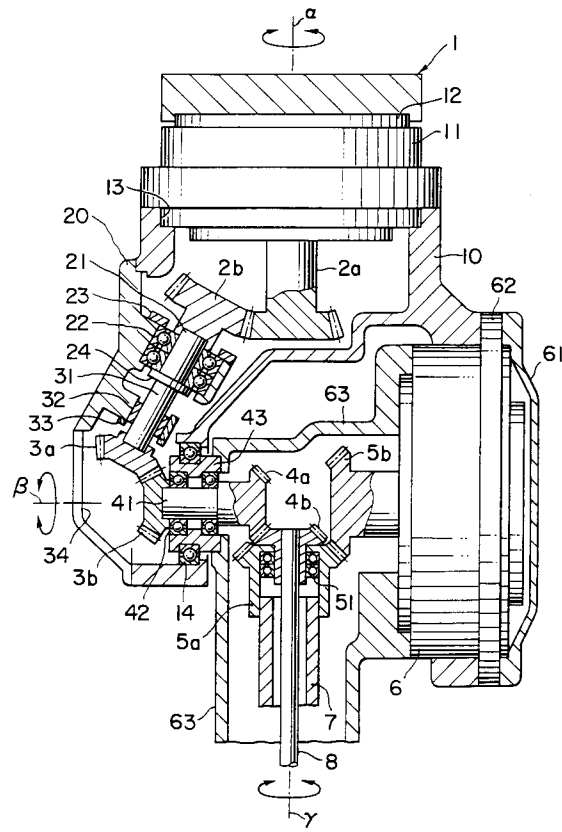


FIG. 1

TECHNICAL FIELD

This invention relates to a wrist mechanism for an industrial robot, particularly to the one in which the swing axis at the tip end of the wrist is aligned on coaxial line with the axial center of the arm.

BACKGROUND ARTS AND THEIR PROBLEMS

In general, the wrist mechanism of industrial robots is the front-end mechanism in which robot operations should be integrated, so that not only revolution and rotation of what is called " α ", " β ", and " γ " axes be universal, but also the mechanism be small in size, smooth in rotational transmission and strong in force. One of the wrist mechanisms for an industrial robot according to the prior art is disclosed by the Laid-Open Japanese Patent Application No. 1988-185595. The side sectional view of the prior art is shown in Fig. 3.

In Fig. 3, the outer rotation shaft 7 is supported by the bearing 51 within the robot arm 63 (" γ " axis) whose speed is reduced by the speed reducer (not shown), and further the inner rotation shaft 8 is supported by the other bearing within the outer rotation shaft 7. One output power transmitted by the outer rotation shaft 7 enters the speed reducer 6 on the " β " axis via the bevel gears 5a and 5b to make up and down rocking (what is called " β " rotation), while the other output power transmitted by the inner rotation shaft 8 enters the speed reducer 11 on the " α " axis via the bevel gears 4a and 4b, the spur gear train 9a, 9b and 9c and the bevel gears 2a and 2b to make what is called " α " rotation of the wrist 1.

In the wrist mechanism for an industrial robot according to the prior art, however, the speed reducer 11 for " α " rotation is arranged on the member 10 at the front end portion of the wrist, and the speed reducer 6 for " β " rotation is arranged close to the inner rotation shaft (8), thus both constituting the last stage of the respective power transmission systems: In more detail, one output power transmitted enters the speed reducer 11 on the " α " axis via the bevel gears 4a and 4b, the spur gear train 9a, 9b and 9c and the bevel gears 2a and 2b to make the " α " rotation of the wrist 1, while the other output power transmitted enters the speed reducer 6 via the bevel gears 5a and 5b to make the " β " rotation. With this configuration, the gear train 9a, 9b and 9c necessitates the idle spur gear 9b for adjusting potential backlash taking place between the spur gears 9a and 9c in an assumed direct engagement of them, thus requiring many pieces of rotating parts, resulting in a large moment of inertia.

SUMMARY OF THE INVENTION

Object

To solve the above problems, an object of the present invention is to provide a wrist mechanism for an industrial robot in which the spur gear train for " α " axis is replaced by a combination of bevel gears, where the intermediate shaft axis intersects at acute angles with the " β " and " α " axes, thus minimizing the number of gears required without changing the original arrangement of the " α " axis speed reducer.

Technical Means for Solving the Problems

To achieve the above object, a wrist mechanism for an industrial robot according to the present invention is characterized in that:

a (first) speed reducer is provided for an " α " rotation, at the wrist portion attached to the tip (or front) end of the robot arm, so as to be in coaxial line with the axis of the robot arm;

a (second) speed reducer is provided for a " β " rotation, at the side of and closer to the robot arm, so as to be at right angle with the axis of the robot arm;

outer and inner rotation shafts are rotatably supported in the robot arm so as to be in coaxial line with the " γ " axis;

bevel gears are attached on the respective tip ends of the outer rotation shaft and the inner rotation shaft;

a bevel gear is provided to the shaft of the second speed reducer so as to engage with the first bevel gear, for receiving a bending power to the " β " axis; and

the second bevel gear engages with a bevel gear attached on one end of a " β " rotation shaft supported at right angle with the robot arm " γ " axis;

a rotation shaft is provided at an acute angle with the " β " rotation shaft so as to be rotatably supported;

bevel gears are attached to one and the other ends of the rotation shaft so as to engage with the mating bevel gears;

a bevel gear is attached to the shaft of the first speed reducer so as to engage with the mating bevel gear for receiving a rotational power to the " α " axis; and

a rotation of the wrist portion is made via the first speed reducer by the input rotation power transmitted from the inner rotation shaft through the bevel gearing.

The above configuration such as the intermediate power transmission shaft making an acute angle (not right angle) intersecting with " α " and " β " axes can not only minimize the number of parts required, but also reduce the moment of inertia of

the wrist mechanism as well as minimize the chance of possible backlash adjustment.

In the above configuration, as described above:

The three spur gears in the gear train for " α " rotation according to the prior art is replaced by one intermediate shaft with two bevel gears at both ends, thus reducing the number of parts and gears, resulting in a further miniaturized and compact wrist mechanism for an industrial robot.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional side elevation view showing an embodiment of a wrist mechanism for an industrial robot according to the present invention;

Fig. 2 is a sectional side elevation view showing another embodiment of a wrist mechanism for an industrial robot according to the present invention; and

Fig. 3 is a sectional side elevation view showing a wrist mechanism for an industrial robot according to the prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Now preferable embodiments of the wrist mechanism for an industrial robot according to the present invention will be described, referring to the accompanying drawings.

Parts in the embodiments according to the invention shown in Figs. 1 and 2, which have the same or similar functions as or to those of the prior art shown in Fig. 3 are given the same numerals and signs as those of the prior art.

In Fig. 1, in the one embodiment according to the present invention:

A first speed reducer 11 for the " α " axis (for wrist rotation) is provided in coaxial line with the " γ " axis (of the robot arm 63) at the front end portion of a wrist portion 1. A second speed reducer 6 for the " β " axis (for wrist bending) is provided at right angle with the " γ " axis (of the robot arm 63) at the side portion of the wrist portion 1 close to the robot arm 63.

First, explanation is made about how to transmit wrist rotational power from the robot arm 63 to its front end component or the first speed reducer 11 for the " α " axis:

Within the robot arm 63 an outer rotation shaft 7 is supported by a bearing 51 in coaxial line with the robot arm 63. Further, within the outer rotation shaft 7 an inner rotation shaft 8 is also supported by the bearing 51 in coaxial line with the robot arm 63. A second bevel gear 4b attached to the upper end of the inner rotation shaft 8 is engaged with a fourth bevel gear 4a screwed onto one end of a

horizontal " β " rotation shaft 41. A fifth bevel gear 3b is attached to the other end of the " β " rotation shaft 41. The fourth bevel gear 4a is rotatably supported by a bearing 42 in a housing 43 fixed to the robot arm 63. The inner and outer rings of the bearing 42 are positioned in place by the housing 43, the shoulder of the " β " rotation shaft 41 and the engagement portion of the fifth bevel gear 3b.

A rotation shaft 31, 24, 21 is provided at an acute angle with the " β " rotation shaft 41. Onto one end of the rotation shaft 31, 24, 21 a sixth bevel gear 3a is fitted so as to engage at the acute angle with the fifth bevel gear 3b. The rotation shaft 31, 24, 21 consists of a collar 24, small diameter section 31 and large diameter section 21. The small diameter section 31 is rotatably supported by a needle bearing 32, which is further fixed by a retaining ring 33 and a housing 20.

The large diameter section 21 is rotatably supported by a bearing 22, which is further fixed by a ring-shape retainer 23 and the housing 20. On the end of the large diameter section 21 a seventh bevel gear 2b is attached so as to engage with an eighth bevel gear 2a attached to the lower end of the " α " shaft connected to the first speed reducer 11.

The first speed reducer 11 is fitted into a recess 13 machined on an upper end of a (rotatable about " β " axis) member 10, so as to rotate the wrist portion 1 about " α " axis by an amplified rotational torque with reduced speed via an output end section 12.

Next, explanation is made about how to transmit wrist bending power from the robot arm 63 to its side end component or the second speed reducer 6 for the " β " axis:

Within the robot arm 63, on the upper end of the outer rotation shaft 7 a first bevel gear 5a is attached so as to be rotatably supported by the bearing 51 (rotatable relative to the inner rotation shaft 8). The first bevel gear 5a is engaged with a third bevel gear 5b attached to the inner end of the input shaft of the second speed reducer 6. The second speed reducer 6 reduces the input rotational speed. An amplified bending output torque with reduced speed is transmitted to the member 10 via an output shaft 62, so as to make a bending (rocking) motion of the member 10. The member 10 is rocking-free supported by a bearing 14, which is further supported by the housing 43. Numeral 61 is a grease cover, and 34 is a normally-closed window opened in a cover 20 for serving to maintenance work such as adjustment or repair of bevel gear backlash or wear. Around the window is provided a seal (not shown) for blocking oil leaking. The cover 20 and the grease cover 61 both serve to oiling to the bevel gears and the rotating parts.

Fig. 2 is a sectional side elevation view show-

ing the other embodiment of a wrist mechanism for an industrial robot according to the present invention:

In this embodiment, the previous input transmission method to the first speed reducer 11 for " α " rotation embodied by the first embodiment is further enhanced for stabilization: More particularly the transmission configuration of rotational torque from the robot arm 63, through the second bevel gear 4b on the inner rotation shaft 8, then to the fourth bevel gear 4a on the horizontal " β " rotation shaft 41 is improved for a more stabilized arrangement of the fourth bevel gear 4a and for eliminating possible irregularities of gear transmission with the " β " rotation shaft supported at both far ends (instead of the previous cantilever construction).

In more detail, a hole is opened in the axial center of the third bevel gear 5b. Through the hole, a bolt 53 is screwed into the input shaft (not shown) of the second speed reducer 6 for bending " β " rotation. Into a recess bored in the third bevel gear 5b a bearing 52 is fitted.

Further, the bearing 52 is fitted onto a boss projecting from the fourth bevel gear 4a, which is further bolted coaxially into the " β " rotation shaft 41 by bolt 46.

On the reducer side of the fourth bevel gear 4a or on the boss a shoulder 44 is provided. The shoulder 44 and a ring-shape retainer 45 position the inner ring of the bearing 52 in axial place from both sides.

As described above in detail, since the wrist mechanism for an industrial robot according to the present invention engages a part (intermediate) of bevel gearing at acute angle with bevel gears on the " α " and " β " rotation shafts, the wrist mechanism can not only reduce the number of gears and related parts, but also the moment of inertia of the whole system, thus remarkably enhancing acceleration/deceleration capability. Further the reduction in number of gear meshes may serve to reduce the man power for adjusting or repairing the possible backlash or wear of the gears.

It goes without saying that, this invention is not limited to the above described embodiments but applies to every other embodiment to the extent the content is not departed from the following claims.

Claims

1. A wrist mechanism for an industrial robot, in which:

a first speed reducer is provided for an " α " rotation shaft, at the wrist portion attached to the tip upper (or front) end of the robot arm, so as to be in coaxial line with the " γ " axis of the robot arm;

a second speed reducer is provided for a " β " rotation shaft, at the side of and closer to the robot arm, so as to be at right angle with the " γ " axis of the robot arm;

outer and inner rotation shafts are rotatably supported in the robot arm so as to be in coaxial line with the " γ " axis;

a first bevel gear is attached on the upper end of said outer rotation shaft;

a second bevel gear is attached on the upper end of said inner rotation shaft;

a third bevel gear is provided to the shaft of said second speed reducer so as to engage with said first bevel gear, for receiving a bending torque inputted from the " γ " axis; and

a bending rotation of the wrist portion is made via said second speed reducer by the input bending torque transmitted through said third bevel gear,

being further characterized in that:

said second bevel gear engages with a fourth bevel gear attached on one end of a " β " rotation shaft supported at right angle with the robot arm " γ " axis;

a fifth bevel gear is attached on the other end of said " β " rotation shaft;

a rotation shaft is provided at an acute angle with said " β " rotation shaft so as to be rotatably supported;

a sixth bevel gear is attached to one end of said rotation shaft so as to engage with said fifth bevel gear;

a seventh bevel gear is attached to the other end of said rotation shaft;

an eighth bevel gear is attached to the shaft of said first speed reducer so as to engage with said seventh bevel gear for receiving a rotation torque inputted from the " γ " axis; and

a rotation of the wrist portion is made via said first speed reducer by the input rotation torque transmitted from said inner rotation shaft through said eighth bevel gear.

2. A wrist mechanism for an industrial robot as claimed in claim 1, wherein

a hole is drilled in the center of said third bevel gear;

said third bevel gear is bolted to said second speed reducer by a bolt screwed into the shaft thereof through said hole;

a bearing is tightly inserted into a recess bored in the end face of said third bevel gear;

a hole is drilled in the center of said fourth bevel gear;

said fourth bevel gear is bolted to the projecting end of said " β " rotation shaft by a bolt screwed into the shaft thereof through said

hole; and

said bearing is tightly inserted onto the projecting boss of said fourth bevel gear.

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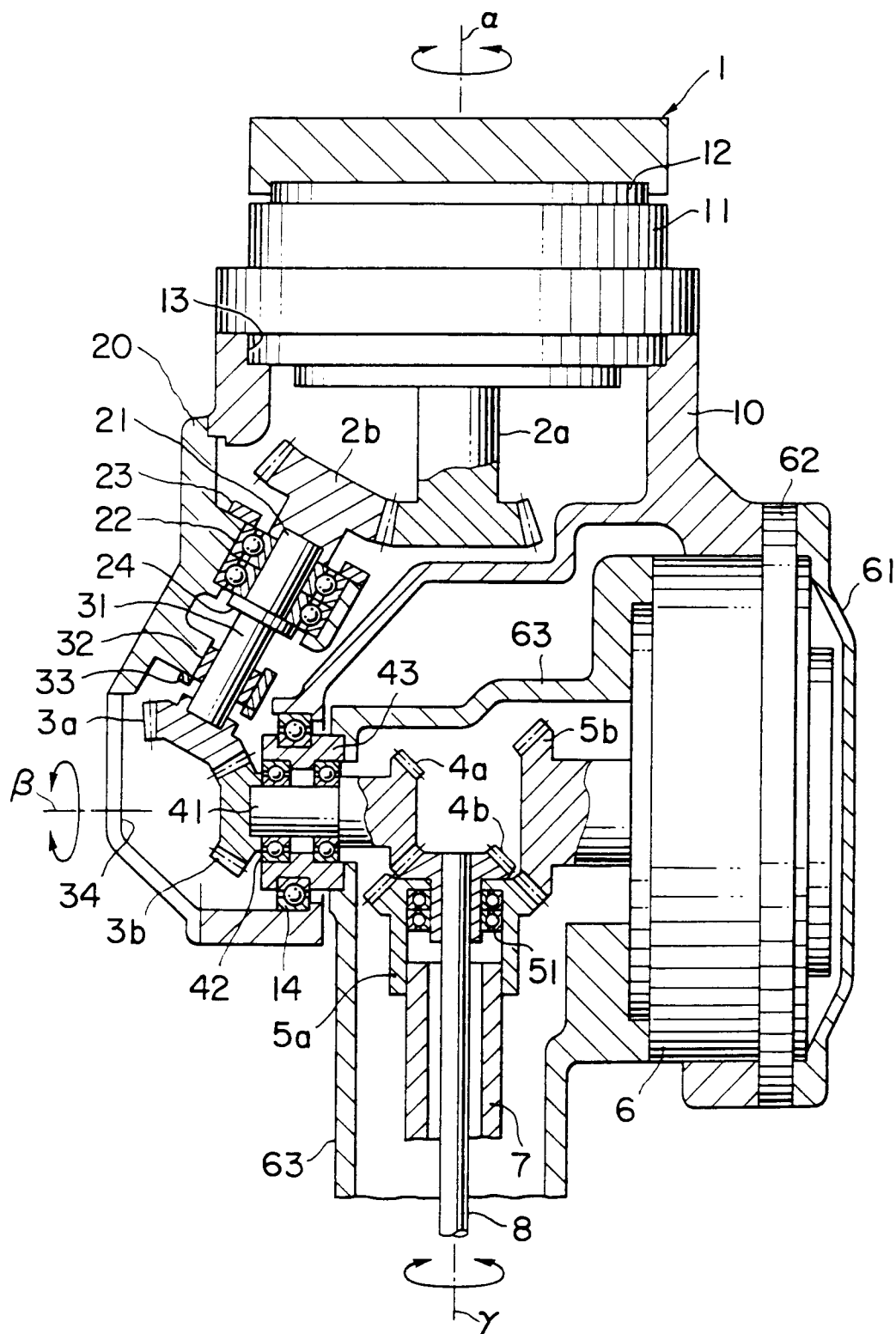


FIG. 1

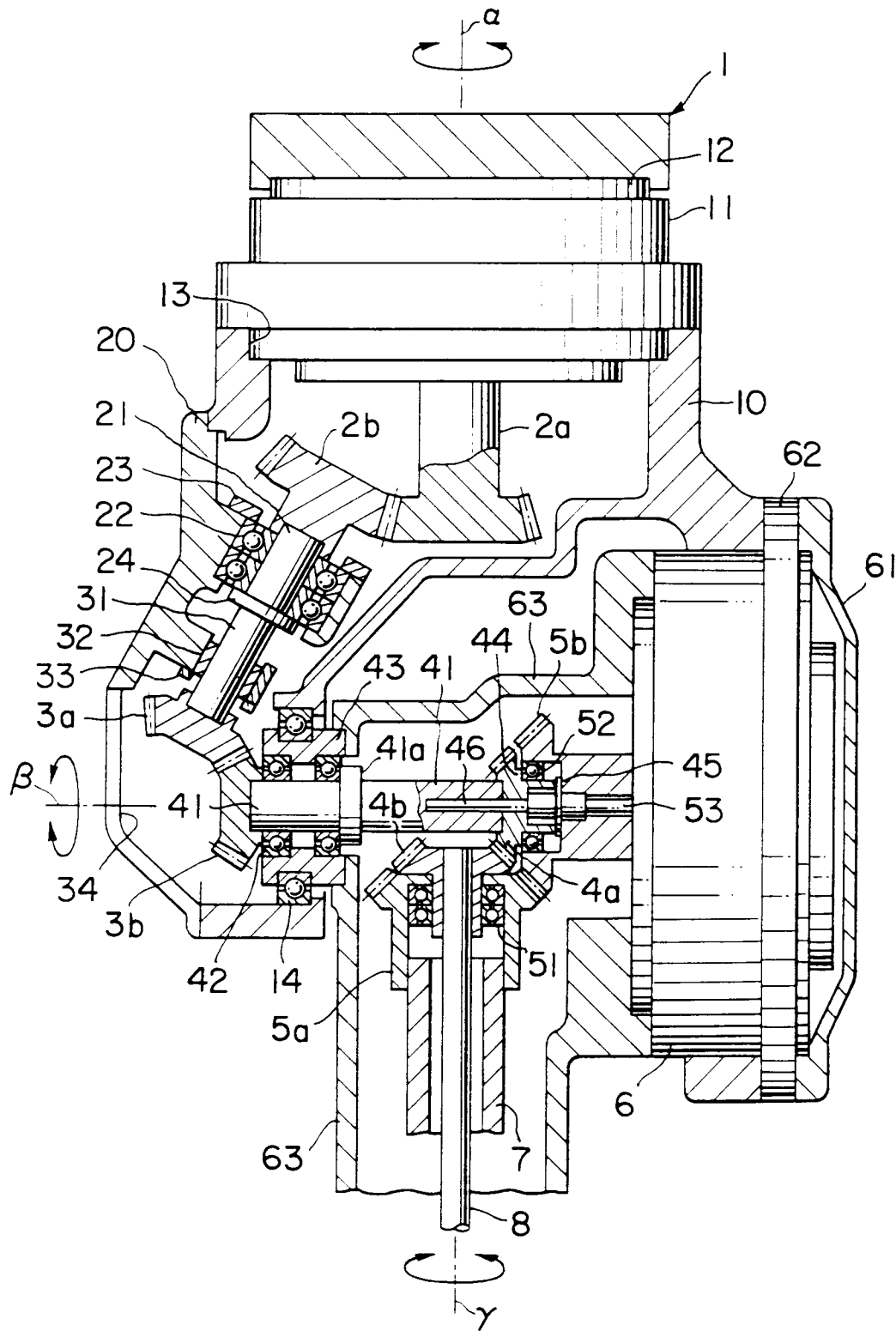


FIG. 2

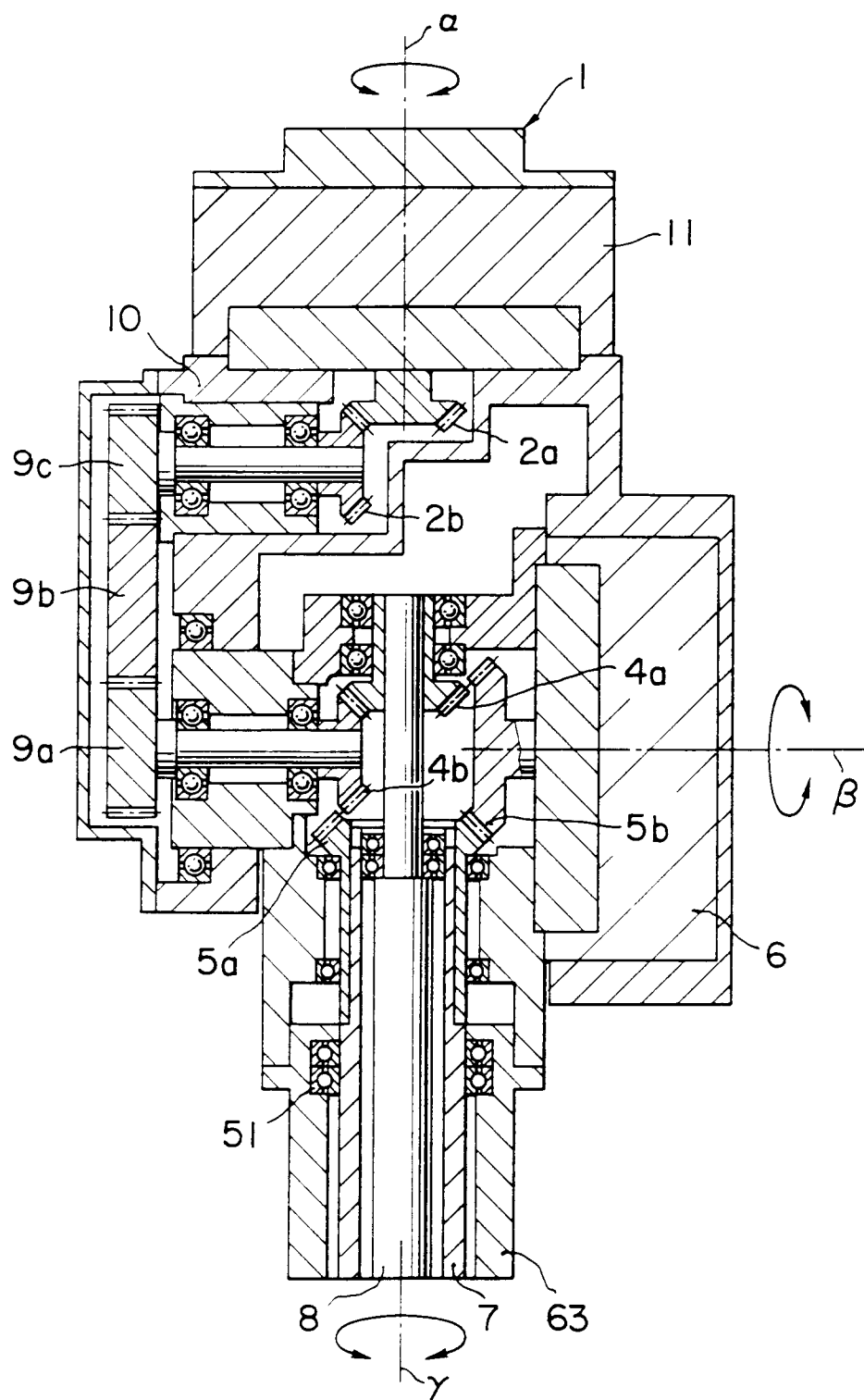


FIG. 3
PRIOR ART

INTERNATIONAL SEARCH REPORT

International Application No PCT/JP92/00088

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int. Cl ⁵ B25J17/02		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC	B25J17/02	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
Jitsuyo Shinan Koho	1926 - 1992	
Kokai Jitsuyo Shinan Koho	1971 - 1992	
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category [*]	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
Y	JP, A, 60-191790 (Canon Inc.), September 30, 1985 (30. 09. 85), (Family: none)	1, 2
Y	JP, A, 52-105463 (Tsubakimoto Chain Co.), September 3, 1977 (03. 09. 77), (Family: none)	1
[*] Special categories of cited documents: ¹⁰ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
April 3, 1992 (03. 04. 92)	May 19, 1992 (19. 05. 92)	
International Searching Authority	Signature of Authorized Officer	
Japanese Patent Office		